Hornsea Project Four: Environmental Statement (ES)

Offshore Nesting Project Description

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Glossary

Term	Definition
Commitment	Hornsea Four, throughout the pre-Application consultation process, has produced a Commitments Register which forms a quick reference guide to commitments the project has made. Commitment is a term used interchangeably with mitigation and enhancement measures. The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are acceptable.
Compensation Measures	The measures that have been developed by the Applicant pursuant to the HRA Derogation Provisions "without prejudice" to the Applicants position of no Adverse Effect on Site Integrity at the Flamborough and Filey Coast in respect of the qualifying features. The Compensation Measures are: [offshore and onshore nesting; predator eradication; bycatch and fish habitat enhancement measures]. Each a Compensation Measure and together Compensation Measures.
Cumulative effects	The combined effect of Hornsea Four in combination with the effects from a number of different projects, on the same single receptor/resource. Cumulative impacts are those that result from changes caused by other past, present or reasonably foreseeable actions together with Hornsea Project Four.
Design Envelope	A description of the range of possible elements that make up the Hornsea Project Four design options under consideration, as set out in detail in the project description and this Compensation Project Description. This envelope is used to define Hornsea Project Four for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement (ES).
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Landfall	The generic term applied to the entire landfall area between Mean Low Water Spring (MLWS) tide and the Transition Joint Bay (TJB) inclusive of all construction

	works, including the offshore and onshore ECC, intertidal working area and landfall compound. Where the offshore cables come ashore east of Fraisthorpe.
Maximum Design Scenario (MDS)	The maximum design parameters of each Hornsea Four asset (both on and offshore) considered to be a worst case for any given assessment.
Mitigation	A term used interchangeably with Commitment(s) by Hornsea Four. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, or PEIR or ES).
Order Limits	The limits within which Hornsea Project Four (the 'authorised project) may be carried out.
Orsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Planning Inspectorate (PINS)	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).

Acronyms

Term	Definition
DCO	Development Consent Order
EIA	Environmental Impact Assessment
ES	Environmental Statement
HRA	Habitats Regulations Assessment
MDS	Maximum Design Scenario
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
PEIR	Preliminary Environmental Information Report
PINS	The Planning Inspectorate
PSA	Particle Size Analysis
SAC	Special Area of Conservation
SPA	Special Protection Area
SSS	Side-Scan Sonar
TCE	The Crown Estate
UKHO	UK Hydrographic Office

Units

Unit	Definition
dB	Decibel (sound pressure)
Hz	Hertz (frequency)

1 Introduction

1.1 Project Background

1.1.1.1 Orsted Hornsea Project Four Limited (the 'Applicant') is proposing to develop Hornsea Project Four Offshore Wind Farm ('Hornsea Four').

1.1.1.2 The purpose of this Environmental Impact Assessment (EIA) Project Description Annex is to provide a description of the proposed Compensation Measures the Applicant may be required to deliver to compensate for potential impacts upon certain seabird species at the Flamborough and Filey Coast Special Protection Area (FFC SPA), located on the East Coast of England. The Compensation Measures are proposed "without prejudice" to the Applicant's conclusion of No Adverse Effect on Integrity (AEoI) upon the seabird species (kittiwake, gannet, guillemot and razorbill) in the Report to Inform the Appropriate Assessment (RIAA).

1.1.1.3 The Hornsea Four offshore wind farm will be located approximately 69 km offshore the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall (at Fraisthorpe), and connection to the electricity transmission network at National Grid Creyke Beck. Detailed information on the project design can be found in **Volume 1: Project Description**, with detailed information on the site selection process and consideration of alternatives described in **Volume 1: Site Selection and Consideration of Alternatives** which are provided on the Hornsea Four website in the Documents Library at:

1.1.1.4 https://hornseaprojects.co.uk/hornsea-project-four/documents-library/formal-consultation

1.1.1.5 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project has given due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

1.1.1.6 The combination of Hornsea Four's Proportionality in EIA and Developable Area Process has resulted in a marked reduction in the array area taken forward at the point of DCO application. Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback..

1.1.1.7 The Applicant is submitting an application for a DCO to the Planning Inspectorate (PINS), supported by a range of plans and documents including an ES which sets out the results of

the EIA on the proposed offshore wind farm and its associated infrastructure, and an Annex to the EIA which assesses the environmental impact associated with the implementation of the proposed Compensation Measures, which are set out in this Compensation Project Description.

1.1.1.8 The Applicant is also submitting a RIAA which sets out the information necessary for the competent authority to undertake a Habitats Regulations Assessment (HRA) to determine if there is any Adverse Effect on Integrity (AEoI) on the national site network as a result of the development of the Hornsea Four offshore wind farm and its associated infrastructure. A separate HRA Screening exercise has been complete for the implementation of the Compensation Measures as presented in **Volume B2, Annex 2.2**.

1.2 The Derogation Provisions of the Habitats Regulations

1.2.1.1 The Habitat Regulations transposed into UK law the requirements of the Habitats Directive. Although the UK left the European Union (EU) on 31 January 2020, the Habitats Directive provides the legislative backdrop to the Habitats Regulations. The Habitats Directive seeks to conserve particular natural habitats and wild species across the EU by, amongst other measures, establishing a network of sites ("European sites") which together form the "National Site Network." The aim is to ensure the long-term survival of viable populations of Europe's most valuable and threatened species and habitats, to maintain and promote biodiversity.

1.2.1.2 The Habitats Directive acknowledges that the imperative of some plans and projects can outweigh the possible harm to a European site if that harm can be adequately compensated. The Directive provides a derogation under Article 6(4) that allows projects that may have an AEoI to be consented. In such a scenario, a derogation could only be provided under Article 6(4) if three tests are met in a sequential order:

i. There are no feasible alternative solutions to the project;
ii. There are "imperative reasons of overriding public interest" (IROPI) for the project to proceed; and
iii. Compensatory measures are secured that ensure that the overall coherence of the network of European sites is maintained.

1.2.1.3 The derogation tests thereby underpin a three-step process, which are hereafter referred to as the "HRA Derogation Provisions".

1.2.1.4 The Habitats Regulations do not define what is meant by or may comprise "compensatory measures" or when they must be delivered. There is also no definition of the "overall coherence of the National Site Network". In principle, both are broad concepts. The limited case law on compensation confirms only:

- Compensation is distinct from mitigation (i.e., measures which prevent, avoid or reduce the harm to the integrity of the affected European site)[1].
- Compensation can be delivered inside or outside a European site[2].

1.2.1.5 As there is no binding EU or UK case law that fixes the precise parameters of or timing for delivery of compensation, there is a degree of flexibility and it will be a matter of judgement for the Secretary of State (SoS) to determine what is "necessary" by way of compensation, acting reasonably and proportionately.

1.2.1.6 The Applicant firmly maintains the position that in respect of the designated sites, that there would be no AEoI as a result of the project alone and in-combination with other plans and projects and an AEoI can be ruled out beyond reasonable scientific doubt. The offshore wind farm and associated infrastructure RIAA will be submitted with the DCO application and will set out the in detail the assessment and conclusion of no AEoI.

1.2.1.7 Nonetheless, in light of the SoS's decision letters for recent windfarm applications (e.g. Hornsea Three and Norfolk Vanguard) that future projects should be mindful to ensure consideration of the need for derogation, including possible in-principle compensation measures are presented for consideration during the Examination of DCO application.

1.3 Development of Compensation Measures

1.3.1.1 The Applicant recognises the importance of engaging with the relevant stakeholders with respect to derogation and developing any potential compensation measures, as their knowledge is important. The Applicant has therefore sought to engage openly and transparently with the key stakeholders.

1.3.1.2 Consultation on the HRA Derogation Provisions has been ongoing in the latter stages of the pre-application stage during the course of a series of online workshops (employed during the COVID-19 pandemic to substitute meetings in-person). The Evidence Plan Process has been followed during the development of the derogation case and included a number of relevant authorities and stakeholders.

1.3.1.3 Throughout the Consultation period, the Applicant has sought the advice of key stakeholders and kept them updated on project developments. The online workshops were attended variably by Natural England, the Marine Management Organisation (MMO), the Department for Environment, Food and Rural Affairs (Defra), the Joint Nature Conservation Committee (JNCC), The Wildlife Trust (TWT), Royal Society for the Protection of Birds (RSPB), National Federation of Fishermen's Organisations (NFFO) the Planning Inspectorate (PINS),

[1] Case C-521/12 Briels and Others, paragraphs 38 – 39.
[2] Case C-521/12 Briels and Others, paragraphs 38 – 39

East Riding of Yorkshire Council (ERYC) and The Crown Estate (TCE). Detail of consultation activity undertaken will be submitted with the DCO application in the Record of Consultation.

1.3.1.4 The Compensation Measures outlined herein could be implemented should the SoS conclude AEoI on any of the qualifying features of FFC SPA.

1.4 Compensation measures

1.4.1.1 This EIA Project Description Annex describes the Compensation Measures that could be implemented to compensate for potential impacts upon ornithological features of FFC SPA. In summary, the potential Compensation Measures proposed, sub-options, locations, location ID and species being compensated are set out Table 1. It is anticipated that for guillemot and razorbill a package of measures could be required, rather than a single compensation measure. Compensation Measure Areas of Search are presented in the accompanying Location Plan (see **Figure 1**).

Table 1: Compensation Measures, sub-options, locations, location ID and species being compensated.

Compensation Measure	Option	Location	Location ID	Kittiwake	Gannet	Guillemot	Razorbill
Offshore nesting	New	southern North Sea	A1				
Offshore nesting	Repurposed	southern North Sea	A1				
Onshore nesting	New	Cayton Bay to Newbiggin by the Sea	B1				
		Suffolk Coast	B2				
Bycatch		Thames Estuary	C1				
		South coast of England: Broadstairs to Plymouth	C2				
Predator eradication		Isles of Scilly	D1				
		Rathlin Island, Moyle, Northern Ireland	D2				
		Torquay, Devon	D3				
		Guernsey and Aldernery	D4				
Fish habitat enhancement	Seagrass	Rathlin Island, Moyle, Northern Ireland	E1				
	Seagrass	Isles of Scilly	E2				
	Seagrass	Celtic Sea, Wales	E3				
	Seagrass	Plymouth Sound to Helford River	E4				
	Seagrass	Solent	E5				
	Seagrass	Essex Estuaries	E6				

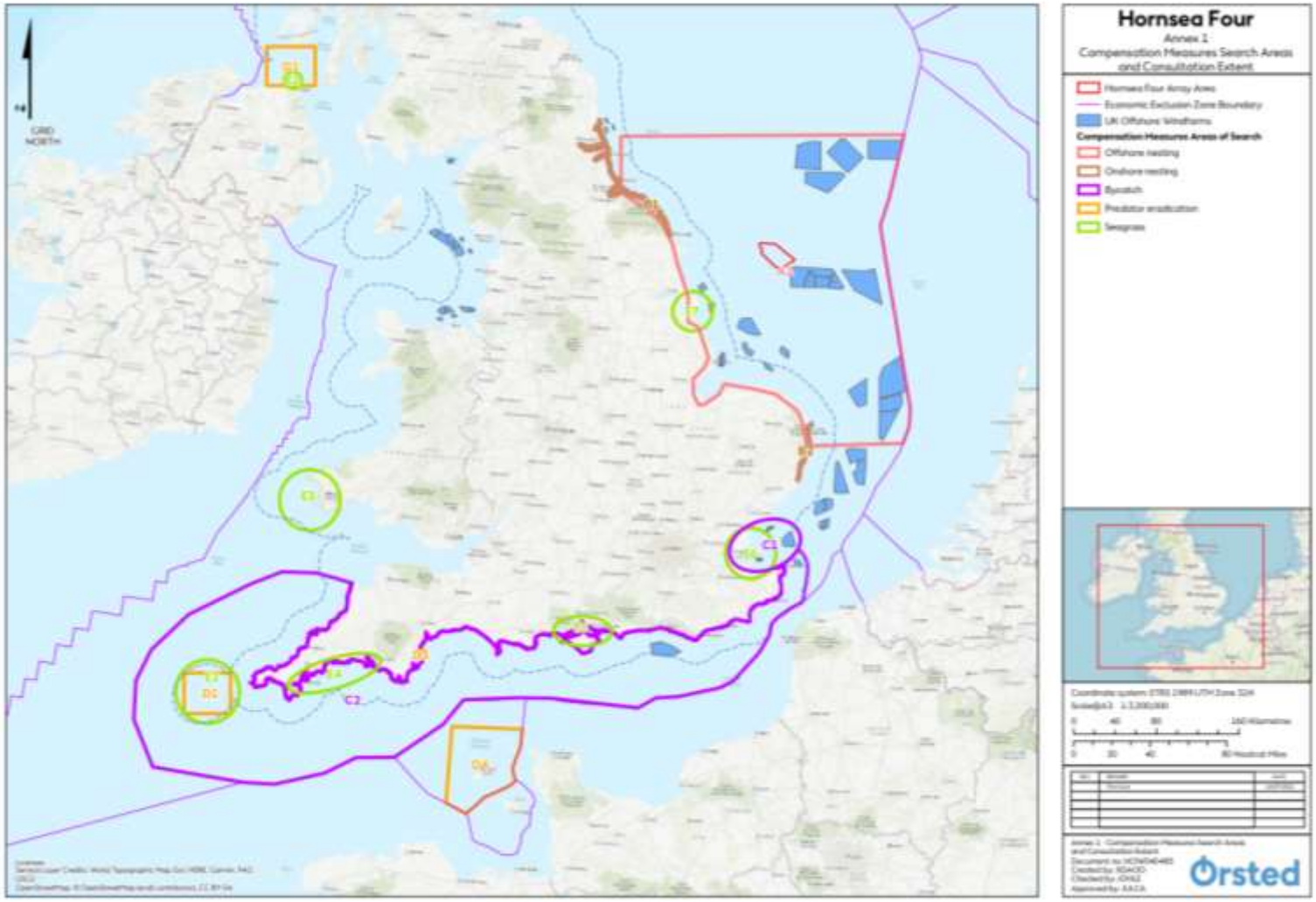

Figure 1: Compensation Search Areas

1.5 Programme

1.5.1.1 The high-level programme presented below is applicable to the implementation and delivery of all compensation measures.

- Anticipated Hornsea Four DCO Granted – Q1 2023
- Compensation implementation licencing – 2022/24
- Compensation Implementation – 2023/24
- Offshore Construction of Hornsea Four Offshore Wind Farm – 2027/28

1.6 Decommissioning

1.6.1.1 The requirement for, and the exact nature of decommissioning the offshore and onshore nesting structures, will be determined in consultation with the relevant authorities towards the end of the 35-year operational life of Hornsea Four. The Applicant will design the structures for a design life equal to that of the windfarm (i.e. 35 years plus 4 years to establish the compensation measures, pre-wind farm operation. Therefore, the lifetime of the structure is approximately 39 years). In the final few years of wind farm operation, the Applicant will commence inspections and surveys of the bird nesting structures to determine if an extension of the lifetime is possible.

1.6.1.2 It is currently anticipated that the predator eradication and bycatch measures implementation will result in new management practices which shall continue for the lifetime of Hornsea Four. Fish habitat enhancement (seagrass) compensation measure sites will be left in perpetuity.

2 Offshore Artificial Nesting Platforms

2.1 Introduction and Background

2.1.1.1 The provision of an offshore artificial nest site(s) to increase the annual recruitment of black-legged kittiwake (kittiwake) into the regional population of the southern North Sea is considered a possible Compensatory Measure for a potential Adverse Effect on Site Integrity at the Flamborough and Filey Coast Special Protection Area (FFC SPA). The Applicant are considering two options by which to achieve this: construction a new offshore nesting structure(s) or repurposing an existing Oil and Gas platform(s) that is due for decommissioning.

2.1.1.2 Kittiwake have been observed readily (APEM, 2021 and Niras, 2021) utilising man-made structures and therefore it is considered that the establishment of an artificial nest site(s) would provide a viable compensation option (see **Figure 2**). Successful establishment of breeding colonies at a site would produce young, which would become part of the wider Eastern Atlantic population of kittiwake, thereby maintaining the coherence of the network of SPAs designated for kittiwake.

Figure 2: Kittiwake nesting on an Oil and Gas Platform in the Southern North Sea.

2.1.1.3 Taking an appropriately precautionary approach for assessment work (i.e. mid-point estimate for mortality rate and dispersal rate of 89%), in order to increase the regional Eastern Atlantic breeding population of adult birds by a sufficient margin to offset the predicted impact of Hornsea Four on an annual basis (i.e. 95 additional adult breeding birds recruited into the population), it is calculated that approximately 526 – 608 additional breeding pairs will be required. The additional population of 526 is based on a natal dispersal rate of 0.890, which is the average cited by Horswill & Robinson (2015) for UK colonies, but this rises to 608 if a worst-case value of 0.770 is assumed instead. Therefore, one or more structures offshore, which can collectively sustain a breeding population of 526 pairs of kittiwakes, would produce enough breeding adults (95 birds per year) to compensate for the estimated potential impact of Hornsea Four on the kittiwake population.

2.1.2 Repurposing Existing Offshore Platforms

2.1.2.1 Hornsea Four has consulted with various oil and gas operators in the Southern North Sea offshore nesting area of search (see Figure 1) for the purposes of identifying opportunities to repurpose an existing offshore platform. Several platforms approaching decommissioning have therefore been identified as potential options. Further work is being done to explore these opportunities.

2.1.2.2 As an example, one platform that has been identified as a potential candidate platform, installed after 2000, having now reached the end of its production life, is a normally unattended installation (NUI), designed to be primarily operated remotely.

2.1.3 New Offshore Platforms

2.1.3.1 Additionally, the Applicant is considering the construction of purpose-built offshore nesting platform(s) within the Southern North Sea offshore nesting area of search (see **Figure 1**). The design, construction and operation of a new offshore platform for the purposes of kittiwake nesting would follow the description contained in the following sections.

2.2 Offshore Platform Design

2.2.1 Repurposing Existing Offshore Platforms

2.2.1.1 The Applicant could utilise an existing offshore platform (potentially an existing oil and gas structure or similar), and use the foundation to:

A. design, construct and install a new topside once the existing topside structure has been removed and decommissioned,
B. repurpose the existing topside structure by adding additional nesting.

2.2.1.2 For example, a platform currently under design consideration consists of a topside platform of 16 x 12.75m area sitting atop a 47m high jacket foundation in 25m water depth. This analogue is used for the preceding description.

2.2.1.3 The design parameters for repurposing an existing offshore platform, are presented in **Table 2.** These existing design parameters may be considered a Maximum Design Scenario (MDS) for sub-option B above (see **Paragraph 2.1.1.1**). It is anticipated that any new topside design for a repurposed topside on an existing foundation (sub-option A in **Paragraph 2.1.1.1**) would fall within this topside MDS.

Table 2 : Maximum design parameters for existing topside structure to be repurposed for offshore nesting.

Parameter	Maximum design parameter
Number of offshore nesting platforms	1
Topside structure length (m)	16
Topside structure width (m)	13
Topside structure height above LAT (m)	19
Topside structure height above foundation (m)	9

2.2.2 New Offshore Platforms

2.2.2.1 The Applicant could design a new foundation and topside for the specific purpose of supporting kittiwake nesting. The maximum design parameters for a new offshore nesting foundation and platform are presented in Figure 3. The MDS for a new offshore platform is presented in Table 3.

Table 3: Maximum design parameters for new offshore nesting platform.

Parameter	Maximum design parameter
Number of offshore nesting platforms	2
Topside structure length (m)	25
Topside structure width (m)	25
Topside structure height (m above LAT)	20
Topside thickness (from topside to upper level of foundation) (m)	10

NOTE: Foundation dimensions are dependent on topside dimensions. Which in turn are dependent upon the design of the final topside, which is dependent upon the number of kittiwakes to be compensated

2.3 Description of topside design

2.3.1.1 At present it has not be determined if a new purpose designed topside could be used on both a repurposed and new structure. Further design and engineering assessment works are required to determine the exact location and technical design criteria for any repurposed structure and comparison to a new structure. For the purpose of this Project Description, it is assumed that the topsides for both the repurposed and new structures are unique to each concept.

2.3.1.2 Ledges on existing offshore platforms (see Figure 2) fulfil many of the natural nesting requirements for kittiwake and may provide additional benefits e.g. fewer predators and proximity to food sources (Christensen-Dalsgaard 2019). At offshore sites, birds appear to choose narrow ledges (c. 14-25 cm) under helidecks and walkways, mainly on unmanned platforms.

2.3.1.3 The overall design of a topside nesting structure is flexible, as long as suitable narrow nesting ledges are present. A summary of the key features an offshore platform for nesting might include is provided below:

- High and steep sided structure, narrow horizontal ledge for nests, small overhang above nest;
- Inaccessible to predators, which offshore would primarily be large gulls; and
- Some shelter from high winds and other adverse weather conditions.

2.3.1.4 In addition, the topside design may include a shelter and potentially CCTV to enable monitoring of the seabirds.

2.4 Description of foundation design

2.4.1.1 New offshore nesting platforms will be fixed to the seabed by a foundation structure. Figure 3 presents graphically the foundation types being considered with maximum design scenario (MDS) parameters. A maximum of two new foundations to support offshore nesting will be created. The technical feasibility of the foundation types will be informed by the acquisition of geophysical and geotechnical survey data collected pre-construction. The exact foundation type will be chosen upon consent, technical and commercial considerations.

NOTE: Foundation dimensions are dependent on topside dimensions. Which in turn are dependent upon the design of the final topside, which is dependent upon the number of kittiwakes to be compensated

Figure 3: Foundation types (indicative only).

2.5 Location

2.5.1.1 The location of an offshore platform in terms of proximity to key foraging areas, such as tidal fronts, is important to increase the chance of avian colonisation of a structure. Further to extensive consultation with the relevant statutory nature conservation bodies (SNCBs), the Applicant has selected the area of search presented in Figure 1.

2.5.1.2 The site selection process for the offshore artificial nesting structures is being undertaken via a heatmapping exercise. Ecological criteria will form a primary consideration, with technical and commercial considerations also considered. The heatmap will be applied using 5km search grids, across the entire search area, each with unique identifying codes. 5km search grids are being used as it is considered that they are large enough to provide the flexibility required for ground conditions to ensure the structures can be suitably micro-sited.

2.5.1.3 Statutory stakeholders have advised that site selection should avoid the core foraging range distance from FFC SPA, and it would be beneficial for the location to be close enough to FFC SPA for colony interchange to be a possibility. The search area for a breeding colony would therefore be located approximately beyond 55km and broadly around 100km from the FFC SPA. We will also take into consideration other environmental information such as information on prey and will take into consideration planned, under construction and operational wind farm locations.

2.5.1.4 In respect of commercial site selection criteria, existing assets have been identified using open data sources from The Crown Estate, including offshore wind farms, minerals and aggregates, offshore mines, oil and gas and dredging disposal sites. Additionally, known future assets, such as Round Four offshore wind farm lease areas and carbon capture, utilisation and storage (CCUS), have been identified. A 500m buffer has been applied to all assets and will be excluded from site selection. The Applicant is undertaking continued consultation with The Crown Estate and operators to ensure commercial criteria used for site selection is appropriate and robust.

2.5.1.5 Further engagement with stakeholders and oil and gas operators is ongoing and additional information is being gathered to inform and refine the site selection process.

2.6 Construction

2.6.1 Repurposing Existing Offshore Platforms

2.6.1.1 Foundation installation is not required if repurposing an existing offshore platform. However minor modifications to the existing offshore platform foundation may be required. Foundation repurposing installation activities could include repairs, modifications, or reinforcement of existing foundation infrastructure and are set out in a maximum design scenario.

2.6.1.2 All modifications would be undertaken using either or a combination of DP and JUV vessels as set out in **Table 4**.

2.6.2 Topside installation

2.6.2.1 Generally, topside(s) are installed using the following process:

- Topsides are installed upon their respective foundation type (see **Section 2.4**);
- Topsides are picked up from port. This vessel will typically be a JUV to ensure a stable platform for installation vessels when on site. JUVs are assumed to have up to six legs

with an average spudcan area of 170 m^2 per foot. In general, the JUV will carry all the components for topside installation on a single trip;

- The installation vessel will then transit to the installation area and the components will be lifted onto the existing transition piece or foundation substructure, by the crane on the installation vessel. Each topside will be assembled on site in this fashion with technicians fastening components together as they are lifted into place. The exact methodology for the assembly is dependent on the topside type (new or repurposed) and installation contractor, and will be defined in the pre-construction phase after grant of consent; or
- Alternatively, the topside components may be loaded onto barges or dedicated transport vessels at port and installed as above by an installation vessel that remains on site throughout the installation campaign.

2.6.2.2 Each installation vessel or barge may be assisted by a range of support and transport vessels. These are typically smaller vessels that may be tugs, guard vessels, anchor handling vessels, or similar. These vessels will primarily make the same movements to, from and around the installation area as the installation vessels they are supporting.

2.6.2.3 The foundation and topside may be transported on the same transport vessel/barge, or separately. The foundation may also be transported by the installation vessel.

2.6.3 Constructing New Offshore Platforms

2.6.3.1 New offshore platforms are generally installed in two stages, firstly the foundation is installed as described in **Table 4**, and secondly the topside will be lifted from a transport vessel/barge onto the foundation (as per **Section2.6.2**). The details presented in **Table 4** are indicative and based on our understanding at this current time. Vessel numbers relate to 2 new foundation and topside structure installations and finalisations.

2.6.3.2 The foundation and topside may be transported on the same transport vessel/barge, or separately. The foundation may also be transported by the installation vessel. The vessel numbers are presented in the MDS.

Table 4: Foundation installation summary for new structures.

	Foundation type				
	Monopile	*Piled jacket*	*Suction bucket jacket*	*Mono-suction bucket*	*Gravity base*
Site preparation (also see below)	Usually minimal. If preconstruction surveys show the presence of boulders or other seabed obstructions at foundation locations, these may be removed if the foundation cannot be microsited.		As well as boulder and obstruction removal this foundation type may also require some seabed levelling, to ensure that all of the buckets / gravity bases for each structure can be placed at the same level. The suction buckets needs to have level ground beneath to form a sealed chamber within each bucket once the foundation has been lowered to the seabed..		
Transport to site	Either on the installation vessel (either JUV or Dynamic Positioning Vessel (DPV)), or on feeder barges.				Brought to site on barges or installation vessels or alternatively they can be floated to site. Structures designed to be buoyant and towed them to site using tugs.
Installation	• Lift monopile into the pile gripper on the side of the installation vessel; • Lift hammer onto monopile and drive monopile into seabed to required embedment depth; • Lift hammer from monopile and remove pile gripper; • Lift transition piece onto monopile; and • Secure transition piece.	• Piling template placed on seabed; • Piles installed; and • Jacket lowered onto piles OR • Jacket lowered onto seabed; and • Piles installed	• Jacket lowered onto seabed; • Water pumped from bucket(s); and • At desired depth, the pump is turned off		Foundations lowered to the seabed in a controlled manner either by pumping in water, or installation of ballast (or both).

	Foundation type				
	Monopile	*Piled jacket*	*Suction bucket jacket*	*Mono-suction bucket*	*Gravity base*
	Where conventional piling is unable to achieve necessary pile penetration, additional methods may be used (e.g. drilling, water jetting, vibro-piling and/or electro-osmosis).	Pin piles are driven, drilled or vibrated into the seabed.			
Finalisation	Transition piece bolted or grouted to the monopile (if required). The grout used is an inert cement mix that is pumped into a specially designed space between the transition piece and the monopile.	As the there is no separate transition piece, there is no requirement for installing an additional structure offshore.	A thin layer of grout is injected under each bucket to fill the air gap and ensure contact between the soil within the bucket, and the top of the bucket itself. As there is no separate transition piece, there is no requirement for installing an additional structure offshore.		None
Topside	Either on the installation vessel (JUV or Dynamic Positioning Vessel (DPV)), or on feeder barges. Brought to site on barges or installation vessels or alternatively they can be floated to site. Structures designed to be buoyant and towed them to site using tugs.				
Installation vessels (return trips per vessel type(DP/JUV))	16				8
Support vessels	64				8

	Foundation type				
	Monopile	*Piled jacket*	*Suction bucket jacket*	*Mono-suction bucket*	*Gravity base*
Transport vessels (barges)	40				16
Transport vessels (tugs)	30				0

2.6.4 Ancillary operations

2.6.4.1 Some form of Seabed preparation (boulder and sandwave clearance), unexploded ordnance (UxO) clearance and Scour protection may be required for each foundation type in Table 4. Seabed preparations are detailed in Section 4.8.8. of the Project Description (see the Hornsea Four Document Library). Unexploded ordnance (UXO), boulder and sandwave clearance for foundations are as per Section 4.8.8. of the Project Description.

2.6.4.2 Scour protection is designed to prevent foundation structures being undermined by hydrodynamic and sedimentary processes, resulting in seabed erosion and subsequent scour hole formation. The preferred scour protection solution may comprise a rock armour layer resting on a filter layer of smaller graded rocks. The maximum diameter of the rocks used would be 1 m and the maximum thickness of scour protection layer would be 2 m.

2.6.5 Maximum design parameters for foundations

2.6.5.1 Each environmental assessment considers the range of foundations options (including monopiles, suction bucket jacket foundations, piled jacket foundations, mono suction buckets and gravity base structures) and assesses the foundation type which presents the maximum design scenario for the relevant receptor(s).

2.6.5.2 Table 5 presents the MDS. Full details of all foundation types considered are provided in Section 4.8.4 of Volume 1: Project Description (see the Hornsea Four Document Library).

Table 5: Indicative Maximum design* parameters for the new offshore nesting platform foundations.

	Maximum design parameters	Maximum related foundation type
Total Number	2	-
Number of Piles (per foundation)	16	Piled Jacket
Piling hammer energy (kj)	5,000 (3,000)	Monopile (if pin piles)
Seabed Preparation Area	3.739 m^2	GBS
Seabed Structure Area	2,206 m^2	GBS
Seabed Scour Protection Area	4,587 m^2	GBS
Seabed Total Permanent Area	6,793 m^2	GBS
Drill Spoil Volume (average; assumes 10% drilling)	264 m^3	Piled Jacket
Seabed Preparation (Spoil) Volume	6,234 m^3	GBS (Large OSS)
Scour Protection Volume	9,173 m^3	HVDC

* NOTE: The MDS is provided based on the assumption of a 39-year design life. Should this be increased then MDS would need to be revisited and any assessments updated accordingly.

2.6.6 Piling

2.6.6.1 The maximum hammer energy for the installation of piles (monopiles and pin piles) for an offshore nesting platform is 5,000/3,000 kJ. It is expected that there may be up to 1 piling vessel on site at any one time. Full details of piling technology and their application, including soft-start and ramp-up, are provided in Section 4.8.4 of the Project Description (see the Hornsea Four Document Library).

2.6.7 Aids to Navigation and marking

2.6.7.1 All surface infrastructure will be designed in accordance with relevant guidance from Trinity House, the Civil Aviation Authority (CAA) and the Maritime and Coastguard Agency (MCA). This will include colours, marking and lighting. The positions of all infrastructure will be conveyed to the UK Hydrographic Office (UKHO) so that they can be incorporated into Admiralty Charts and the Notifications to Mariners (NtM) procedures.

2.6.8 Safety Zones

2.6.8.1 During construction and decommissioning, The Applicant will apply for a 500 m safety zone around infrastructure that is under construction.

2.7 Operation and Maintenance

2.7.1.1 This section provides a description of the reasonably foreseeable maintenance activities for an offshore nesting platform. Maintenance activities can be categorised into two levels: preventive and corrective maintenance:

- Preventive maintenance will be undertaken in accordance with scheduled services; and
- Corrective maintenance covers unexpected repairs, component replacements, retrofit campaigns and breakdowns.

2.7.1.2 The overall operation and maintenance strategy will be finalised once the nesting concept has been decided, operation and maintenance base location and technical specification are known, including final project design.

2.7.1.3 The general operation and maintenance strategy may rely on an onshore (harbour based) operation and maintenance base, Crew Transport Vessels (CTVs), Service Operation Vessels (SOVs), offshore accommodation, supply vessels and helicopters. The final operational and maintenance strategy chosen may be a combination of the above solutions. The maximum design parameters for general operation and maintenance activities are presented in **Table 6**, as trips per year. The O&M activities exclude any monitoring requirements which will be determined in consultation with the relevant authority's post-consent.

Table 6: Maximum design parameters for general offshore operation and maintenance activities.

Parameter	Maximum design parameters
Operation and maintenance vessels - CTVs:	24
Operation and maintenance vessels - SOVs	24
Jack-up vessels	24

2.7.2 Operation and maintenance activities

2.7.2.1 The following section describes the processes and methods the Applicant would undertake for those activities for which consent is sought. This includes regular and scheduled operation and maintenance as well as unscheduled maintenance that is likely to occur. Some activities which could be needed in the operation and maintenance phase have not been included in this application as it is considered that these would be best applied for at a later date, if needed, once specific details of the requirements are understood. Descriptions of offshore operation and maintenance activities are provided in **Table 7**. The MDS parameters will depend on the lifetime of the Compensation Options (see **Section 1.5**)

Table 7: Offshore operation and maintenance activities.

Activity	Rationale	Parameter	Maximum design parameter
Seabed surveys	Seabed surveys will be required to ensure that the scour protection around foundations remains intact. Typically, this will be undertaken more frequently in early years, hence the assessment is based on twice yearly for first three years; followed by yearly thereafter	Maximum number in lifetime	5
Marine growth	Marine growth will be physically brushed off (where required) followed by high-pressure jet wash (sea water only). Technicians and equipment will be deployed from a CTV or similar vessel.	Maximum number of cleaning events – lifetime quantity (per platform)	35
Foundation anode replacement	This includes the removal and replacement of anodes, which are required for corrosion protection (internal and external to the foundation). These sacrificial anodes, usually zinc, are fastened to an external structure. The metal erodes away preferentially and so protects the erosion of the foundation steel. Anode replacement works are likely to be undertaken via divers from a dive support vessel. One turbine anode replacement event is planned per turbine every five years.	Maximum number of anode replacement events – lifetime quantity (per platform)	5
		Footprint of seabed disturbance per event (m^2)	300

2.8 Decommissioning

2.8.1.1 The requirement for, and the exact nature of, decommissioning will be determined in consultation with the relevant authorities towards the end of the 35-year operational life of Hornsea Four.

2.9 Monitoring and Adaptive Management

2.9.1.1 Monitoring forms an integral component of the Compensatory Measure and will be developed with relevant stakeholders. The delivery of the Compensation Measure will be planned with relevant monitoring of kittiwake undertaken at appropriate timescales to maximise its usefulness to Hornsea Four and the wider scientific community. The success in deployment of the artificial nest structures will be monitored through observations of the number of breeding birds and their breeding success. Monitoring of these rates will follow the standard methods provided by Walsh et al., (1995) and specified by the Joint Nature Conservation Committee's (JNCC) Seabird Monitoring Programme which acts as the hub of seabird population information. Collection of seabird data in this format will permit comparisons to be made with on-going monitoring at existing colonies along the east coast of England, including that undertaken at the FFC SPA (Babcock et al., 2018). In order to monitor the number of breeding birds and their breeding success whole colony counts and productivity monitoring will be conducted at the artificial nest site. The precise nature of monitoring at the structure will be influenced by the final form and locations the Compensation Measure takes. In addition to monitoring, it is likely that further research will also be undertaken such as on seabird prey and Hornsea Four are engaged in ongoing discussions with stakeholders on the potential research topics.

2.9.1.2 The Compensation Measure is a long-term commitment, with monitoring and adaptive management built in to ensure the long-term success of the measure. Adaptive management is an iterative, post-consent process which combines management measures and subsequent monitoring with the aim of improving effectiveness whilst also updating knowledge and improving decision making over time. Adaptive management will be an important component of the Compensation measure and will be used as a method to address unforeseen issues or deviations from expected time scales (i.e. colonisation rate of structure). Adaptive management measures are designed to support the Compensation Measure once functioning (post construction) as a way of furthering the success and supporting resilience of the measure. It is worth noting at this stage that any adaptive measures will be thoroughly discussed and explored with relevant stakeholders prior to the implementation of any option.

2.10 Summary of Offshore Artificial Nesting Structures

2.10.1.1 Artificial nesting structures (offshore structures new and repurposed) are considered to be primary Compensation Measures. New or a repurposed structure would each be capable of delivering the level of compensation required with greater capacity available. A detailed evidence report will be submitted with the application which demonstrates the evidence to support the scale and efficacy of the compensation measure ensuring that significant contingency is built into the measure to provide the necessary confidence that it will substantively offset the impact. These Compensation Measures are effective, feasible and securable measures that can be implemented prior to the impact occurring and sustainable for the lifetime of the project. Further details of the compensation plan and roadmaps to delivery will be provided with the DCO application submission. The Applicant has undertaken engagement with statutory and non-statutory stakeholders including The

Crown Estate and oil and gas operators throughout the development of these measures and consultation will be ongoing.

3 References

3.1 Introduction

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